WAR MEDICINE

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SURGICAL TREATMENT OF WAR WOUNDS.[1]

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As the present war has brought out entirely new military problems, so has the preconceived notion of treatment of wounds required entire revision. The wounds inflicted today are by new forms of projectiles, the supply of which in contrast to former methods is absolutely lavish. Deep trench warfare has rendered the soldier a filthy and constantly contaminated person, particularly the trenches of Flanders and Northern France, dug in soil which for centuries has been saturated with manure and other fertile sources of infection.

The treatment of war wounds is a highly specialized branch of surgery, and the rules of civil practice apply hardly, if at all, at the front. Moreover, we have to deal with a different kind of individual than in civil practice. In the latter phase the factory hand who is badly hurt will, however, have been in good condition immediately prior to his injury, will have come from clean surroundings, his person and clothing will be relatively uncontaminated, will recently have had food and drink and will not have been exposed unduly, and perhaps for a long time, to the effects of cold and wet. When injured some form of competent relief is almost immediately at hand and transportation to a well-equipped hospital usually speedy and comfortable. Moreover, the treatment at this institution can usually be given promptly. The elements of fear and anxiety and the strain of prolonged expectation of injury are likewise absent.

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[1] Read before the Medical Society of the State of New York, May 23, 1918.

The wounded soldier will probably have been subjected to harassing conditions of warfare. His injuries may be multiple. It may be some time before he is picked up and in addition to the other conditions he may be deprived of food and drink, especially the latter, for a long period of time. The journey out of the trenches is long, tedious, hazardous and may greatly add to the patient's shock. It is therefore obvious that special training for proper treatment of such cases must be obtained and must be derived from practical experience at the front and cannot be replaced by theory.

The three main factors of wounds are (1) shock, (2) hemorrhage and (3) sepsis. The latter element in this war is almost 100 per cent. possibility. Soon after the outbreak of hostilities it was generally conceded that this constant element of sepsis must be combated by something more than the usual line of treatment for every-day trauma.

In addition to laying open wounds freely, three things quickly developed, namely, the importance of early treatment, no matter what kind, the bad effects of leaving projectiles and other foreign bodies in the wounds, and the necessity of actual destruction of the bacteria. The first has been met by constantly moving up better organized lines of relief closer and closer to the front. At the present time it is aimed, if possible, to do such thorough and early surgery close to the lines that relatively little remains to be done at the rear. It becomes obvious that even by modern antiseptics no foreign body, usually contaminated as they are, could be sterilized by any method, no matter how efficient or thorough.

Credit is due to Dr. Carrel and his co-workers who have demonstrated that although bacteria can be very efficiently combated in the tissues at almost any stage, these methods fail in the presence of foreign bodies. Also proceeding on these lines it becomes evident that tissues which were damaged made favorable places for bacteria and were of themselves a source of danger.

It was pretty clearly demonstrated in 1916 by Carrel and some of those who followed his methods accurately, like Depage at LaPanne, that the Carrel method, providing the patient came under treatment early and was submitted to thorough operation, namely, free excision of the tract of the missile and the removal of all foreign bodies, acted as an efficient prophylaxis against infection.

It will be appreciated that even with the demonstrated efficiency of chemical sterilization, good surgery applied at a very early stage was almost a *sine qua non*, and, in fact, chemical sterilization became an adjuvant and not a substitute for good surgery.

The Carrel method is well known or should be. In order to be efficient it must be done rightly. To be done rightly requires a series of steps requiring infinite care and continued treatment under the same conditions. It is quite impossible, under the unusual circumstances of warfare, to give the great bulk of wounded men who come to hospitals near the lines in large numbers, and in a short space of time, such treatment.

The present-day generally accepted method as practised by the Allies on the Western Front aims at prophylaxis of wound infection by a method which, in some ways, is simple, and if it can be carried out efficiently gives such good results as to minimize the necessity of complicated or prolonged after-treatment. The present-day method aims at the radical excision of all open wounds, removal so far as feasible of all foreign bodies, be they what they may, and the complete removal of all bruised, infiltrated, damaged or "shocked" tissue. Operations done on this principle and done thoroughly by highly competent surgeons, with a large experience in this particular line of work, give the surest guarantee against the development of all forms of sepsis, particularly the dreaded gas gangrene.

It has been my privilege to observe the workings of this method in both the British and French Armies. The principles in both armies are about the same, varying only in minor degrees and particularly in those of organization. This radical excision of wounds is usually done in the British Army in the so-called "Casualty Clearing Station," which will be situated ordinarily from five to ten miles back of the lines.

The wounded soldier is first brought to a dugout back of the trenches where first aid is administered and then to the dressing station, say one to three miles back of the lines at the end of the communication trenches, at a place where ambulances, motor or horse, can come with comparative safety.

The casualty clearing stations are mostly under canvas. Their units can be multiplied readily. In so-called "peace" times they have approximately 200 beds and a medical staff of 6, which can be increased to 800 or more beds and a medical staff of approximately 25. The patient is brought in carefully warmed ambulances, usually under a sufficient amount of anodyne to diminish shock, both physical and psychical. He is carefully unloaded in a waiting room which is well warmed and protected from drafts and passes into an examining room when his wound and condition are carefully investigated by a highly trained and competent physician who decides on the various steps he will need.

A very few cases of apparently simple conditions may be transferred directly to a base hospital from the casualty clearing station, but the majority of the cases will need some form of operative procedure. The minor cases which form a large group are handled by a special surgeon and a special department and their conditions taken care of either with or without a local anesthetic or with "laughing gas." A certain group of cases may require operation, but their conditions are so precarious that it must be postponed until the patient can be brought back into better condition. These are sent to a special department, called the Resuscitation Ward, where they receive special attention and where there are special resources. Emphasis is placed on heat, particularly heat as given in hot-air baths. The administration of fluid is important as the dehydration of these patients add to the gravity of their conditions. When these patients seem in a condition to stand operation they are returned to the "pre op room," where all the patients await their turn to go into the operating room. Patients requiring an operation which is perhaps not very urgent may wait in the "pre op room" several hours, giving precedence to the more urgent cases. The patient is still kept very warm and is cleaned up to the extent his condition will allow. Badly shocked patients are little disturbed, their clothing being removed on the operating table when they are anesthetized. When the patient comes to the operating theater he is operated on by the surgeon, the head of the surgical team.

A surgical team consists of an operating surgeon of recognized capacity, a physician who acts as anesthetist and at other times does work around the hospital, particularly in the after-care of patients, a nursing sister who acts as assistant surgeon and instrument nurse and a trained orderly. These teams, which generally have been working together for many months, make for the highest efficiency and organization. These teams now bring with them a portable operating table and a supply of routine instruments. This system allows the localization of both personnel and apparatus when it is needed and under most economical management.

The English group their major operating in one single operating theater. This system makes for distinct economy of space and equipment and I have never seen any evidence of confusion arising from this method. (This plan is in contrast to the French system in which each surgeon has his own cramped and very small operating room.) The patients are, for the most part, given a general anesthetic, having already received in transit a generous supply of morphin. The skin is disinfected by mechanical cleansing with soap and water and 5 per cent. alcoholic picric acid solution, which is very efficient and non-irritating.

The surgeon is guided also in some cases by roentgen-ray pictures. In times of greater activity many roentgen-ray examinations have to be omitted and it is only in "peace" times that an appreciable amount of plates can be made, the patient having to be examined under the fluoroscope. The French have developed their fluoroscopy and other means of foreign body localization to perhaps a higher degree than the British and seemed supplied with rather better material resources.

The operation having been conducted along the lines already stated, it is customary in both armies to swab out the wound with some form of antiseptic, the most popular being ether, why, I do not know. Rather small and superficial lesions can be sewed up like ordinary operative wounds, but in the British Army the deeper wounds are more likely to be packed with gauze soaked in paraffin oil containing some form of antiseptic. One per cent. iodoform seems to be the most popular.

These patients are then returned to the wards, most of them to be evacuated on the first hospital train if their condition permits. While it is the aim of the casualty clearing station to evacuate patients for military and psychical reasons as soon as possible, it is generally planned to keep head, chest and abdominal cases one week.

At the base, wounds are redressed and packing removed at a varying time, usually on the average from five to six days. It is stated that the condition of the wound then allows of early suturing in layers and that the results are generally good. I have no means of corroborating this statement from personal experience, but I believe it to be true.

In the French Army primary suture of these wounds is done rather more freely than in similar institutions of the British Army and considerable reliance is placed on cultures; but if the culture shows a streptococcus or Bacillus perfringens the wound is immediately laid wide open and treatment of the open wound is instituted, either by the Carrel method or some other method as the operator practices.

With the French Army this means a somewhat closer relation between the H. O. E. (Evacuation Hospital) and the bases. Moreover, the French, so far as possible, like to have the base hospitals in which the work is to be continued only a relatively short distance away. It is the belief of the best surgical minds in France that a hospital situated at a point farther away than 40 to 60 km. does not really perform the function of an acute hospital but rather that of a convalescent home.

I deem it inexpedient to go further into the treatment of war wounds when they have been transferred in the later stages to the base hospital. The farther away from the front and the longer the time that elapses from the injury, more do the conditions resemble those of civil practice, and it is not my purpose to enter into consideration of these.

I recommend a pamphlet entitled "Surgical Treatment of War Wounds, in the Medical Units of the Third Army, British Expeditionary Force, with Special Reference to Casualty Clearing Stations, February, 1917," which gives thoroughly and more in detail some of the points I have touched on in this article. I append two articles from this pamphlet:

RECEPTION AND DISTRIBUTION OF CASES IN A CASUALTY CLEARING STATION.

BY CAPTAIN E. W. N. WOOLER, R. A. M. C.

Reception of Cases. On arrival, patients are sent to the reception room or rooms. If only one is available it is partitioned so that lying cases go to one side of the partition, walking cases to the other. It is better, however, to have separate huts for each class. Their names are entered in admission and discharge books. They are then sent to separate dressing rooms, one for lying cases and one for sitting cases. In case of a big rush, accommodations for 100 to 200 cases or more should be available near the reception huts, where patients may be put before their names can be taken. This prevents the ambulance cars being held up unduly.

Dressing Room. The dressing room for lying cases should have accommodation for about 8 cases on folding tables at one time. These wooden tables should be substantial, and are made in such a way that when the stretchers are placed on them the poles of the stretchers fall over the sides of the tables and so facilitate the dressing of patients. They are arranged in two rows of four, each of the two medical officers on duty dealing with the cases in one row.

Annexe. A part of each dressing room is screened off to form an annexe for the performance of minor operations.

Distribution from Dressing Rooms. A. *Lying Cases.* All cases fit to be evacuated to the base forthwith are sent to marquees or huts, where they are fed and otherwise attended to until a train is available.

The following is a rough classification of those cases which are detained:

1. *Abdominal Cases.* Abdominal cases in which penetration of the abdomen is suspected. Wounds of the chest, especially of the lower part, of the lumbar region, sacrum or buttocks should always lead one to examine carefully for abdominal symptoms.
2. *Chest Cases.* Chest cases in which penetration of the chest is evident from the urgent symptoms present. Other cases in which penetration is merely suspected or very doubtful can be evacuated at once.
3. *Head Cases.* A large proportion of head cases, namely, those with "compression" symptoms or which show undoubted evidence

of injury to the brain, especially if brain matter is exuding from the wound.

4. *Gas Gangrene.* Cases of gas-infected or suspected gas-infected wounds, *e. g.*, a limb showing tension even though there is no evidence of actual gas formation.

5. *Femur.* Cases of compound fracture of the femur and all other fractures which cannot be thoroughly cleaned up and efficiently splinted in the dressing room.

6. *Oozing.* Cases of deep-seated hemorrhage, even though the vessel concerned is not a large one. Many men arrive in an exsanguine condition, owing to their wounds having oozed steadily all the way down; but the appearance of the wound at previous dressings has not led each succeeding M. O. to attach much importance to it. By the time the man arrives at the casualty clearing station he has lost quite a considerable amount of blood.

7. *Shock, External Hemorrhage.* All cases suffering from shock, external hemorrhage, etc., unfit for evacuation, whether cases of above types or not, *e. g.*, cases of multiple wounds.

8. *Flesh Wounds.* A variety of flesh wounds which do not admit of immediate evacuation, or which cannot be dealt with in the operating annexe, *e. g.*, a limb showing a large wound (but no fracture), with considerable destruction of muscle tissue. The extent of operation required may be beyond the limits of the annexe with gas anesthesia, and the case should therefore be sent to the theater.

DISPOSAL OF CASES. 1. *Abdominal Cases,* if fit for immediate operation, are sent to the preoperation room for preparation. If unfit for operation at the time of admission, they are sent to the ward set apart for resuscitation of cases, or to the special abdominal ward.

2. *Chest Cases.* Chest cases are sent to wards set apart for them.

3. *Head Cases.* Head cases are sent to the preoperation room.

4. *Gas-infected Wounds.* Cases of gas-infected wounds are sent to the preoperation room.

5. *Compound Fracture of the Femur.* These cases as well as some other fractures are sent to the preoperation room.

6. *Hemorrhage.* Cases of deep-seated hemorrhage are sent to the preoperation room.

7. *Flesh Wounds.* Cases of flesh wounds are sent to the preoperation room.

8. *Shock, etc.* Cases suffering from shock or effects of severe hemorrhage are sent to the resuscitation wards.

The M. O. in charge of these wards (preoperation, chest, and resuscitation) notifies the surgeon-in-charge as soon as a case is fit for operation or develops symptoms necessitating immediate operation. Cases suffering from active hemorrhage which cannot be dealt with in the dressing room should be notified to the surgeon-in-charge of the theater at once.

General Principles Guiding the M. O. in Deciding Whether to Evacuate or Detain a Case. 1. If there is any tension, edema or inflammation around the wound.

2. The presence of a thin brownish discharge which exudes under pressure.

3. An odor "fecal" in character.

4. If the wound is one in which gas-infection is likely to develop if left alone, *e. g.*, a small wound of entrance which has become wholly or partially occluded and in which there is much laceration of deeper parts.

If the condition of a wound is satisfactory and presents none of these appearances or if its condition can be dealt with in the operating annexe, such a case may be evacuated. The presence of any one or more of these phenomena, which is outside the scope of the annexe, should lead to the case being detained and sent to the theater.

5. Some cases which have been lying out for several days and are suffering from the effects of exposure and starvation should be detained, although their wounds might admit of their being evacuated.

6. Finally, attention must be paid to the number of cases accumulating for the theater, and should that number become large—say 40 or over—cases may have to be evacuated which would otherwise, for the sake of safety, be sent to the theater. Their wounds should be opened up by well-placed incisions. This can sometimes be done without anesthesia, *e. g.*, in a transverse wound, by incision on the distal side where the nerve supply has been cut off.

Annexe to Dressing Room. This consists of a part of the dressing room, screened off and fitted up for the performance of minor operations under gas or ethyl chloride anesthesia. By having such an annexe the theater, which is always working at high pressure, is relieved of a certain amount of operative work, and the routine work of the dressing room is thus interfered with less than if operations are carried out in it. There is also the additional advantage that other men do not see anesthetics being given nor operations being carried out.

Type of Case and Extent of Operation Suitable for Operating Annexe. 1. Cases of gunshot wound in which a foreign body can either be felt or seen projecting beneath the skin and which can be easily removed. When, *e. g.*, abdomen or joint is implicated, such cases *must* go to the theater.

2. Cases of gunshot wound in which enlargement of the wound will afford better drainage and lessen the risk of the wound becoming occluded and developing a gas infection.

3. "Simple," in the strict sense of the term, as opposed to "compound" fractures, *e. g.*, of the femur, for application of a Thomas splint.

4. All cases of compound fracture which require redressing and reapplication of the same or another type of splint, but which do not call for immediate theater treatment. This only applies to cases in which the wound is freely open and there is no great comminution of bone as all severe compound fractures should be sent to the theater.

5. Lastly, if the pressure on the theater is great, a few cases in which a limb is practically severed may be dealt with and amputation completed, provided other considerations, such as the general condition of the patient, admit of this procedure. As the stumps in most of these cases will require extensive trimming, amputation is not recommended for the annexe except under conditions of extreme pressure.

Following the administration of gas, etc., cases should be detained in the annexe for a quarter of an hour before being sent to the evacuation shelters. This principle is of more importance with reference to cases which have received theater treatment and are suitable for evacuations.

ORDINARY CASES WHICH SHOULD BE "TAKEN DOWN" WITHOUT FAIL IN THE DRESSING ROOM. 1. When dressings are soaked with blood.

2. When splints are not applied properly or when unsuitable splints have been used.

3. When swelling has occurred, particularly in distal parts of limbs, which may indicate "concealed" hemorrhage.

4. When genuine complaints of much pain are made, especially if of recent development, possibly indicating a gas infection.

5. Every case of gunshot wound of the head. Many cases with severe fracture and with brain matter exuding *walk* into the dressing room.

SCHEME OF LABELING. In the distribution of lying cases from the dressing room it is necessary to employ some scheme of labeling in order to avoid confusion. The larger proportion of cases will be found fit for evacuation (probably about three-quarters), and these are marked with a red label bearing the letter "E." Other cases are labeled with a label, the color differing according to whether the case is intended for chest wards, preoperation room or resuscitation wards, etc., each label bearing the name of the ward in addition. By combining the name of ward with a distinctive color, there should be no mistake on the part of the stretcher-bearers as to the allocation of a case. Except in the case of red "E" labels, the numbers of which must be unlimited, the number of other labels for chest and resuscitation wards should correspond to the number of beds available in each ward. The labels are sent back to the dressing rooms as the patients are evacuated and are kept there in a special box for each sort. In this way the M. O. knows when such a ward is full. By checking the number of labels issued for the preoperation room an indication of the amount of work awaiting the theater staff can be obtained.

Walking Cases. In dealing with "walking cases" the same general principles are followed as with the lying cases and the same scheme of labeling is employed.

A small operating annexe for minor operations is also screened off for the same type of case and with the same scope of operation as in the lying cases.

Cases for Evacuation from the Dressing Rooms are sent, "sitters" to a large shelter, lying cases to special marquees in the Evacuation Department, where they can be fed and otherwise attended to. Marquees are available also where sitting cases can go and lie down if they wish to, pending the time for their evacuation by train. If there is much delay, many of these cases will require dressing.

The Preoperation Room. The preoperation room should be capable of holding at least 30 to 50 cases on stretchers. Every case for operation, except those mentioned above for special wards, passes through this room before going to the theater, and is undressed, shaved, etc. In this way the wards are spared a great deal of unnecessary work, as no case for operation, unless specially collapsed, etc., is taken to any ward until it leaves the theater. In addition the patients benefit by remaining on the stretchers until they are put on the table, and have not to be lifted from stretcher to bed, or *vice versa.*

Some Impressions Gathered in the Dressing Room. *Question of Frequency of Dressing.* A very large number of both lying and walking cases have been brought in which have been dressed at the regimental aid post, advanced dressing station, main dressing station, and, in some cases, finally at the corps dressing station, before reaching the casualty clearing station. On an average these dressings have been done during a period of six to twelve hours. So far as the walking cases are concerned, this appears a waste of time and of dressing material, and in lying cases, especially those severely wounded, is, in addition of very doubtful value from the point of view of the patient.

In order to lighten the work at a casualty clearing station it would be well to develop the work at main dressing stations in a more specialized way, *e. g.*, by having an experienced officer to select cases, serious ones, including all fractures, not requiring immediate attention, to be sent on at once to the casualty clearing station; lighter cases, likely to be able to travel to the base, to be carefully dressed and labeled in some way to indicate that they need not be dressed again at the casualty clearing station, whether labeled in this manner or not. It will be made evident, from the papers which are to be read, what points require special attention from M. O. S. in field ambulances, etc.

In a general way the rule should hold that no dressing should be changed unless there is some definite indication for it.

The Arrangement of Work When Two or More Casualty Clearing Stations are Working in Conjunction. 1. *Each May Be on Duty for Twenty-four Hours at a Time.* This is most practicable in quiet times, but during an offensive one the casualty clearing station alone may not be able to deal with all the cases which may arrive in that period; and, again, it frequently happens that under this scheme one casualty clearing station is worked very hard for one period of twenty-four hours while the other is comparatively quiet in the succeeding twenty-four hours. Lastly, during a period of this length, cases for operation accumulate and many have to wait even until next day before they receive attention. The danger of gas gangrene developing under this system is evident.

2. *Each casualty clearing station* receives a definite number of cases (*e. g.*, 200) and is then relieved by the other. The disadvantages of this scheme are twofold. In the first place the receipt of 200 cases may not be any indication of the amount of work which has to be done. For instance, three-quarters of the 200 may be walking cases, and therefore the amount of operative work involved is light compared with that which may fall to the lot of the other casualty clearing station should their 200 be composed of a large proportion of lying cases. The danger of gas gangrene involved in the accumulation of cases and consequent delay in treatment is almost as great in this scheme as in the first.

3. *Each casualty clearing station* received a definite number of cars alternately (*e. g.*, six cars).

This scheme appears to have none of the disadvantages of the other two. The danger of gas gangrene through delay in treatment is greatly reduced and the work is divided evenly between the two units. A disadvantage may lie in the fact that both casualty clearing stations will be more or less on duty continuously, owing to the small number of cars taken by each, and therefore will never have a rest for long. But it is upon this small number that the efficiency of the scheme depends.

Conclusion. Such is the scheme I would recommend for the reception and distribution of cases, based on three months' experience of dealing with large numbers. The whole basis of the scheme depends upon one main factor—that of deciding in the dressing rooms what is to be done with each case as opposed to any other scheme whereby such decision is arrived at in the wards.

SOME PRINCIPLES OF TREATMENT OF GUNSHOT WOUNDS.

BY CAPTAIN C. H. UPCOTT, R. A. M. C.

After two and a half years of war there is still great divergence of opinion on the subject of wound treatment. This is partly due to the fact that military necessities make it impossible for any one man to have cases under observation from the time when the first surgical treatment is undertaken until complete recovery. Many men have written lauding this or that form of treatment, but their observations refer only to a certain period in the history of a wound, and they are generally concerned with the powers of some particular chemical application to hasten the healing process. This quest of the healing balm continues, and, I think, obscures the one common point where all agree—the need for free enlargement of the wound. It is of this exteriorization of wounds that I wish to speak.

It must be understood that my remarks are confined to the work of a casualty clearing station, I have no other experience. I have been guided by the behavior of wounds during the few days the patients have remained in the casualty clearing station and by occasional reports from the base on the later progress of cases.

Most cases arrive at a casualty clearing station between six and twenty-four hours after the infliction of the wound, and, provided the patient's general condition permits of it, the sooner the wound is attended to the better. This proviso as to the condition of the patient raises one of the most difficult problems with which we have to deal. A patient arrives profoundly shocked by his wounds, the cold, and the superadded trauma of the journey. The usual methods for treating shock are applied: warmth, fluids, rest and the alleviation of pain.

Recently transfusion of whole blood has been widely advocated. While in some cases the immediate revivifying effect of this procedure is striking, in many the benefit appears to be no more than could be attributed to the bulk of fluid injected. In cases suffering from combined shock and hemorrhage it may be that the blood introduced merely goes to fill the venous pool of the relaxed abdominal vessels. Tight bandaging of the limbs or abdomen is always applicable and should be used in conjunction with transfusion. Apart from blood transfusion the subcutaneous or rectal infusion of saline or glucose remains our chief stand-by in the ward treatment of severe shock. The glucose issued in the form of powder appears to be infected with moulds and solutions made from it soon become turbid, even after sterilization. Indolent abscesses sometimes occur at the site of subcutaneous glucose solution, which may perhaps be attributed to this cause. In the early stages of anaërobic infection the intravenous infusion of sodium bicarbonate is of great value. As a stimulant in these cases a hypodermic injection of 10 minims of a 10 per cent. solution of camphor in olive oil should be given and repeated if necessary.

After a few hours there may be a slight improvement in the patient's general condition; then the symptoms of shock merge into those of an overwhelming toxemia suggestive of "acid intoxication." The pallor becomes more marked, the breathing more shallow and often sighing, the feeble pulse, formerly imperceptible, becomes increasingly rapid, while the temperature remains low. The patient often vomits; his mind is alert, but there is little complaint of pain. These are the early signs of deeply spreading anaërobic infection, so liable to occur in wounds of the buttock or thigh, and unless an operation is performed promptly the patient will die. The difficulty lies in choosing the moment to stand an operation and before he has been weakened by the toxemia. I am accustomed to rely chiefly on the character of the pulse; as soon as it can be felt at the wrist a one- to two-hourly record of its rate should be kept, and if this shows a progressive speeding up you have an urgent indication for operation.

It is well to bear constantly in mind the state of affairs existing in a gunshot wound, and the objects to be attained by operation. A missile passing through a limb dissipates a considerable amount of its energy in the tissues; they are struck a terrific blow and the greater the resistance they offer the more energy will the projectile lose in its flight. When the resistance is enough to arrest, for example, a bullet, it is obvious that all the energy of the missile is spent in the body. It does not follow, however, that the tissue injury caused by a lodging wound is greater than that from a traversing wound; the special gravity of lodging wounds depends on other factors. Given an equal resistance to its passage, the higher the velocity of the projectile, the greater the damage inflicted on the tissues. And this damage is not limited to the track of the missile; it imparts its momentum to everything in its line of flight, so that a radiating area of vibration is set up destructive to cellular life. If the tissues vary in density; the more compact will be driven through the more yielding, with a shattering effect.

This is the first point of importance; the immediate destructive effect of a projectile is not limited to its path.

The second point is that practically every wound is permeated with foreign material bearing aërobic and anaërobic organisms, and some of the latter are capable of thriving in the devitalized tissues among which they are sown.

The object to be attained by operation is a widely open wound, from whose surfaces all foreign matter and dead tissue have been removed.

TYPES OF WOUNDS. The types of wounds are so manifold that any classification is difficult, but they may be placed in three groups, to provide headings for the discussion of treatment.

1. *Simple Perforating Wounds in Which the Track is of about the Same Diameter as the Skin Aperture.* An example of this group is a bullet traversing at long range the soft tissues of a limb. Entry and exit are small and the damage to muscle is slight.

The majority of these wounds require no operative treatment, or, at most, excision of skin and fascia. Depending probably on the state of the muscle as regards contraction at the moment of impact, small entry and exit wounds are sometimes accompanied by great destruction of muscle; such cases belong to group 3.

Wounds caused by shrapnel balls have certain peculiar features. Here you have a smooth spherical projectile of low velocity. Having penetrated the skin, its smooth rounded surface enables it easily to find a passage through the muscles, often without causing much surrounding disturbance, but its velocity is so low that it is very frequently held up in meeting tissue of greater resistance. Indeed, it is remarkable how often shrapnel balls are found lodged beneath the skin after having perforated the body or a limb. If the ball and other foreign material are removed, and the entry wound excised, the track does not often cause trouble, although one would think that the wad of clothing carried in ahead of the ball would give rise to serious infection.

2. *Wound in Which the Destruction of Skin and Superficial Tissues is of Greater Extent than the Destruction of Deeper Tissues.* In such wounds as these (gutter wounds, explosive exits, superficial lacerations, avulsions) the wound is more or less exteriorized and all that is required is the excision of all the damaged tissue, in order to attain the ideal of an open wound with a living, uninfected surface.

If this can be assured, the new wound may be closed by primary suture, but unless one can be absolutely certain that the whole of the original wound surface and underlying "shocked" tissues have been removed without infecting the new wound, suture should not be attempted.

3. *Wounds in Which the Skin Aperture is Small in Relation to the Extent of Damage Inflicted on Deeper Structures.* Such wounds may be divided in: (*a*) lodging wounds; (*b*) traversing wounds.

This group includes the majority of wounds; and, apart from injury to important structures, these are the wounds that most urgently call for surgical treatment.

Technic. 1. *Sterilization of the Skin.* Hairy parts should be shaved. If the skin is heavily caked with mud a scrub with soap and water is advisable; in most cases that may be omitted. Cleanse the skin by rubbing with swabs, wet with an antiseptic, such as Dakin's fluid or eusol, for two or three minutes; follow by rubbing with methylated spirit for one minute. During this process the surface of the wound should be covered with an absorbent swab, so that its discharge may not escape and soil the skin. With a pair of forceps, pack the wound with gauze dipped in 5 per cent. alcohol solution of picric acid (or 10 per cent. iodin).

In the case of a wound of group 3 this allows one to ascertain the direction of the track, a search that is often aided by moving the limb in different directions.

Finally, paint the skin with the picric solution and allow to dry while the towels are being placed in position. I have found that skin treated thus can be rendered sterile. The process may often be carried out during the induction of anesthesia. Hurry and lack of method in cleaning the skin will result in failure to achieve sterility.

2. *Excision of Gutter Wound* (*Group* 2). The raw surface of the wound is dried and repacked with gauze; it is then completely encircled by an elliptical incision, which should not be less than one-fourth inch from the edges of the wound. It is advisable to complete one side of the ellipse first, cutting deeply through skin and fascia together, and then deepening the cut rapidly until it has reached beneath the deepest part of the wound. This incision is then packed with gauze while the other half of the ellipse is made, so cutting out a wedge of tissue enclosing the wound and not opening into it at any part. The use of a finger in the wound sometimes enables one to cut clear of pockets which would otherwise be opened. If this be done the same finger should be kept in the wound until the excision is completed; it is then disinfected or the glove changed. All bleeding is carefully stopped and the wound closed with silkworm-gut sutures, which should just emerge in the depth of the wound as they cross from side to side. Gum-mastic varnish, or better, "aëroplane dope," makes a good dressing, and the limb should be firmly bandaged to prevent effusion. If the original wound is opened into at any part during the operation, primary suture should not be done, but the edges may be lightly drawn together over a salt pack or the wound may be left open and sterilized by the Carrel-Dakin method.

3. *Excision of Traversing Wound with Explosive Exit* (*Group* 2). Pack the wound firmly with gauze. Enter the knife vertically not less than one-quarter inch from the edge of the wound, and keeping the blade parallel with the sides of the wound, cut all the way around it, deepen the incision if needed until the apex of the wound is reached, thus making a cone-shaped excision of the wound. Dressing may be either a small central tube to the track of the missile surrounded by salt pack or by Carrel-Dakin.

4. *Tunnel Wounds* (*Group* 3). Draw a strip of gauze through the tunnel and connect the entrance and exit wounds by an incision, cutting down on to the gauze, discard the soiled knife, and excise the wound as in 2. Narrow tunnel wounds should not have a rubber drainage tube drawn through them. This only blocks discharge, and if near a bloodvessel it is liable to cause ulceration of its walls.

5. *Traversing Shell Wounds* (*Group* 3). Entry and exit should be excised by elliptical incisions. Usually it is unnecessary to excise more than one-quarter inch of skin around the wound. As a general rule the area of skin excised varies inversely with the skill of the surgeon. In doing this the knife should be plunged through the skin parallel to the track of the missile and an attempt made to excise the tissues around the wound to the depth of the knife blade in one piece. The crushed muscle and aponeurosis in the deeper parts of

the wound are seized with tissue forceps and cleanly excised. If sufficient access is not provided by the original wound excision the ends of the ellipse should be prolonged, so that the sides of the wound may be retracted. It is well to remember that prolonged and forcible retraction of muscle is liable to crush its tender fibers and render them a prey to saprophytes in the wound. The need for powerful retraction may be avoided by the use of free incisions. In dealing with the deeper parts of the wound it is to be remembered that the gravest danger arises from infection with gas-producing bacilli, which grow most readily in dead and dying muscle. The following points are important:

1. If a muscle is deprived of its blood supply it will not bleed when cut and will probably die.
2. A dead muscle will neither contract nor bleed when cut.
3. A muscle in the first stages of invasion by anaërobes (possibly when poisoned by toxine) loses its normal resilience and has a peculiar brick red color.
4. In the later stages of invasion the muscle becomes crepitant and exudes a dark reddish-brown foul-smelling fluid.

Taking singly the most important of these signs is absence of bleeding on section. A muscle may fail to contract when cut so that if this sign is present alone the muscle need not be excised.

6. *Lodging Shell Wounds* (*Group* 3). These are to be dealt with on the same lines as 5 (traversing shell wounds), with the addition that every effort should be made to find and remove the shell fragment and any particles of clothing carried in with it. To this end exploration by sight is more valuable than by the sense of touch alone, whether roentgen-ray localization has been done or not. In these cases it is sometimes difficult to find the track of the missile. If the skin and fascial wound be excised and then the limb be removed, so that the muscles and skin assume different relative positions, the track will become visible and its direction may be gently explored with the finger and excised. In cases in which the metal fragment is lodged among pieces of bone in positions where the wound cannot be opened up I have found the Mackenzie-Davidson telephone probe of great service.

Lodging wounds often need a counter incision, either for the purpose of removing the projectile or to provide drainage. The objection to dependent drainage openings if the Carrel-Dakin treatment is to be adopted must, however, be borne in mind.

7. *Multiple Wounds.* These deserve separate mention on account of their frequency and by reason of the special problems they present. The condition of the patient often will not allow one to deal with each wound as thoroughly as could be wished. The first thing to do is to determine the general direction of the projectiles. A search will generally reveal a graze, a gutter or tunnel wound, giving a clue to the course of the others. It then remains to decide which

wounds should be first dealt with. Excluding fractures or penetration of the body cavities, lodging wounds of the buttocks, thighs, calves, shoulders and root or the neck should receive preference. If "time" presses, other wounds may be simply laid open by an assistant, and a salt tablet wrapped in wet gauze laid loosely in each.

HEMOSTASIS. At the conclusion of all these operations great care should be devoted to hemostasis, for pools of blood allowed to accumulate in the corners of the wound favor the progress of sepsis. Seeing that these wounds are accompanied by much crushing of tissue a plentiful supply of thrombokinase will be present, and once the larger vessels are secured, oozing may be stopped by pressure.

LOCAL REST. Local rest to the injured part is to be secured by firm dressings—and in this respect the salt pack is valuable—or by splints. The use of supporting splints should not be confined to fractures and joint injuries. Further, wounded muscles which have a large excursion on movement of neighboring joints, should be immobilized by fixing those joints.

AFTER-TREATMENT. In regard to the care of a wound after operation; although I know that sterility may be procured by the strict application of Carrel's methods, I am equally certain that these methods are not feasible during a heavy rush of work at a casualty clearing station, however satisfactory they may be in "peace" times.

I believe that for the majority of wounds, after correct operative treatment, the salt pack is the best dressing in times of pressure. But it must be carefully and exactly applied; a little extra time devoted to the proper application of the dressing is repaid by the absence of any further need for disturbance of the wound during the short time that the patient remains in the casualty clearing station. Wounds involving the main vessels of a limb, and fracture with much comminution, are not suitable for the typical salt pack.

I am fully conscious of the inadequacy of this paper; the subject involves so much tedious detail that the principle of wide excision has been ruthlessly applied in its preparation; but I have tried to lay stress on what I believe to be the most important part of the treatment of a wound—its early operative cleansing—without infringement on the subjects of those who are now to deal with regional surgery.